Changing consumer behaviour in virtual reality: A systematic literature review

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ABSTRACT

Virtual Reality (VR) has evolved rapidly and has been increasingly used in research aimed at promoting behaviour change within consumer domains, particularly since the introduction of head-mounted displays (HMDs). The aim of this systematic review is to examine 1) the validity of VR in this type of research (i.e. is behaviour in VR accurately captured, compared to behaviour in real-life), and 2) the effectiveness of using VR as a tool to change behaviour in consumer domains. 24 articles (27 studies) are included in this review. The findings indicate that VR can potentially be validly used in consumer research aimed at behaviour change in a consumer setting, as findings in real-life were mostly replicated in VR (or vice versa), though the number of studies is relatively low and were mostly conducted in the food domain using student samples. Furthermore, studies which used VR as a behaviour change tool were generally effective in changing consumer behaviour in desired directions, more so than when less immersive (2D), equivalent treatments were used. Future research can focus on extending behavioural research frameworks to include VR in their scope and applying more interactive VR environments to more fully take advantage of VR possibilities for consumer research.

1. Introduction

In recent years, sitting on a sofa at home and at the same time experiencing things like making a loop in a roller coaster, or being on a beach resort has been made possible as a result of virtual reality (VR). VR is a relatively novel technology that enables users to experience three-dimensional environments that emulate artificially created spaces (Lanier & Biocca, 1992). These computer-generated virtual environments can have interactive properties, which are experienced from a first-person point of view (Jason, 2016; Lanier & Biocca, 1992), thus providing the opportunity to make users experience as if they actually are present in a different environment. In the early stages, VR was expensive to develop and use, resulting in only small-scale highly professional applications; consumer applications of VR were very limited in these initial years of VR. For example, VR was used in more professional applications, as a methodological or as an intervention tool in training programs regarding social skills (Howard & Gutworth, 2020), treatment for anxiety and related disorders (Carl et al., 2019), and physical rehabilitation (Howard, 2017). However, as VR technology has further developed it has

become more readily available and easier, as well as cheaper, to use for a wider range of applications. From a technological perspective, virtual reality is rapidly improving and is increasingly succeeding in presenting seemingly realistic virtual environments to its users at a relatively low-cost (Castelvecchi, 2016; Siegrist et al., 2019). Especially the development of head-mounted displays (HMD) has shifted VR use away from only professional applications towards widespread consumer use (Desai, Desai, Ajmera, & Mehta, 2014; Fox, Arena, & Bailenson, 2009; Lanier et al., 2019). Moreover, these developments also increase potential uses and applications of VR in different scientific domains. Consequently, applications of VR in research have expanded in social sciences studies in recent years, also with regard to consumer research.[1]

There are three primary ways through which VR has been integrated into social sciences research, and particularly into consumer research (Fox et al., 2009). Firstly, VR has been studied as the object of consumer research itself. This stream of research has investigated to what extent certain consumer experiences in VR are comparable to similar experiences in real-life (e.g., Siegrist et al., 2019). The main objective of these type of studies is to explore how comparable, reliable and/or valid the

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[1] Our literature review yielded the following number of papers for research papers dealing with VR after our first title screening: 224 papers for 2019, 170 for 2018, 115 for 2017, and 121 for 2016 (2020 is not mentioned here as our literature review did not account for the whole year).

use of VR is, and hence to what extent behavioural studies can be conducted in VR in a manner in which the findings are generalizable to real-life settings. Secondly, VR has been used as a method to investigate consumer behaviour and relevant contextual mechanisms or changes that can affect this behaviour, providing a richer and more in-depth understanding of how consumers make decisions, in a relatively low-cost manner. Due to the apparent sensation of realism of the perceived virtual environment, VR can allow for consumer experiments that are not possible due to contextual or financial restraints and allow to test different future scenarios with a real-life feeling. For example, VR allows for the possibility to study how changes in product presentation or information can affect consumers' likelihood to purchase a product (Goedegebure, van Herpen, & van Trijp, 2020). Or when attempting to experimentally increase donation behaviour, VR can be used to show a potential natural disaster area (e.g., places were a tsunami or hurricane took place, or a refugee camp that provides shelter for people who have lost their home due to a disaster) in a much more cost-effective manner as producing a similarly realistic experience otherwise (Breves, 2020), even more so, when considering that the only similar option is to actually fly the people to the natural disaster area. Thirdly, the application of VR has been of interest to researchers that seek means to test behavioural interventions in a consumer context beyond possibilities in the laboratory and real-life. This third category of research also deals with novel consumer research approaches that only have become possible due to the availability of VR, such as the use of VR in tourism which allows consumers to have an impression of being virtually at a holiday location before purchasing a journey (e.g. Willems, Brengman, & Van Kerrebroeck, 2019), as opposed to for instance having consumers only see 2D pictures of such a holiday location. While VR allows for such more novel experimental designs, it also provides the ability for researchers to completely control the environment of an experiment, similar to the control researchers have in a lab environment. Field studies have good external validity, though they are difficult to control and extraneous factors that are beyond researchers' control can also affect study outcomes. Lab studies have good internal validity, though they have less external validity, for example products tested in a laboratory elicit lower product acceptance in real-life (King, Hottenstein, Work, Meiselman, & Cronk, 2007; Köster, 2003). Thus, VR has the potential to explore research questions in realistic and controlled settings, thereby potentially combining the best of both worlds. The broad spectrum of use cases of VR in consumer research suggests that it is not only a novel research methodology that can mimic existing methods in a more (cost-)effective manner, but that the technology also has potential to have added value in terms of exploring certain research questions or changing behaviour in ways that would be more costly and less feasible without the use of VR.

Besides the advantages that applying VR in consumer research can have, using a relatively novel methodological tool such as VR also asks for a critical reflection. While VR is a potentially useful novel tool in a consumer researcher's toolbox, it is not clear yet to what extent VR truly is as versatile as one might assume in conducting more novel types of consumer research aimed at behaviour change. For instance, experiences in VR have often been accompanied by users experiencing feelings of motion sickness (for a review, see Kim, Park, Choi, & Choe, 2018), also when using head-mounted VR sets (Munafo, Diedrick, & Stoffregen, 2017). Such feelings of motion sickness would likely not occur when conducting the same study in either a lab or field setting. Furthermore, while VR applications seek to replicate reality in a virtual context, in some instances the current level of technological readiness of VR might come with certain obstacles. Virtual models of objects can be limited by the computational power of the VR device; due to these technical limitations, objects are noticeably angular and therefore not always seen as completely 'realistic' by users. Creating a highly realistic environment in VR can be very time-consuming for researchers, and also still be quite expensive (van Gisbergen, Kovacs, Campos, van der Heeft, & Vugts, 2019). It should be noted that differences in perceived realism of an environment in VR overall has no effect on user experiences or behaviour

in the VR environment (van Gisbergen et al., 2019). However, it is likely that there is a lower-bound limit for how realistic a virtual environment should at a minimum be in the perception of VR users, in order to create a sufficient level of immersiveness to have an effect on behaviour. While investigating the technical details of VR is beyond the scope of this review, such technological considerations are something to keep in mind when designing a study involving VR.

As the use of VR in behaviour change research in consumer contexts is emerging, an overview of VR studies in the context of behaviour change in a consumer context is not available yet. Such an overview of existing studies can contribute to advance the field of changing consumer behaviour in VR, by examining the ecological validity of VR studies (i.e. are the findings generalizable to real-life) and to establish the extent to which the use of VR can lead to behaviour change in consumer domains, ultimately culminating in a research agenda that formulates research gaps which can further advance the field when these are addressed. More specifically, we aim to add to the existing literature in the following ways. First, several literature reviews and meta-analyses have evaluated the suitability of VR, in terms of being able to validly measure behaviour, in other areas within the social sciences, such as for instance the use of VR to affect performance of athletes (Neumann et al., 2018) or the use of VR for patient rehabilitation purposes (García-Bravo et al., 2019). However, to our knowledge no paper has yet examined the suitability of VR in consumer research, in terms of its ability to capture and measure consumer behaviour validly, in a systematic manner. Yet, such a comprehensive review is critically necessary, because of the expanding use of VR within consumer research, hence highlighting a need to establish whether such studies accurately capture real-life forms of consumer behaviour. Second, as the research on VR is emerging quickly this askes for an overview including all recent and relevant studies in which VR has been used as a tool to change behaviour in a consumer context, to examine the effectiveness of VR as a behaviour change tool. We focus on the last five years because VR is developing rapidly and is currently more technologically advanced than in the period before (Castelvecchi, 2016), particularly through the use of head-mounted VR sets. Thus, the aim of our systematic review is three-fold: (1) Examine the extent to which VR is a methodologically valid tool to measure consumer behaviour in comparison to more traditional research methods (i.e. to what extent do VR consumer studies lead to comparable findings relative to the same study conducted in a non-VR setting such as a real-life, field setting), (2) Examine the extent to which VR is an effective tool to steer behaviour of consumers through interventions conducted in a consumer domain (i.e. to what extent does an intervention in VR lead to behaviour change, even more so than when consumers are exposed to the same treatment in a non-VR manner such as for instance a video or 2D photos). By addressing these two issues, this systematic review effectively summarizes the current state of the use of VR in consumer research, in terms of both methodological validity in using VR in a consumer context and the ability of VR to create behaviour change. This summarization allows us to address our third goal: 3) the formulation of a research agenda that can potentially further enhance the future applicability of VR in behaviour change research in consumer contexts.

2. Method

2.1. Selection criteria and search strategy

Our first two goals of this systematic review are: 1) to explore the validity of virtual reality as a methodological tool in consumer behaviour research, and 2) to identify the extent to which virtual reality is an effective tool to instigate consumer behaviour change through a behavioural intervention. We did not focus on a specific type of behaviour change or consumer domain, in order to get a generic, robust perspective on the methodological validity as well as effectiveness to change consumer behaviour within virtual reality across various consumer domains (e.g. food, clothing, tourism, charity) and types of behaviour change (e.g.

change in monetary expenditures, items selected or behavioural intentions versus actual behaviour).

In order to ensure accuracy and transparency in the review process, a series of steps is generally recommended (Sargeant, Rajic, Read, & Ohlsson, 2006). In operationalizing these steps, we defined the following criteria to use for the search string: (1) since our focus lies on behaviour change, the study should have some kind of experimental design (e.g., RCT, quasi-experiment), (2) at least one of the study's outcome variables should be some kind of behavioural measure, either objectively measured or self-reported, and (3) some form of virtual reality has to be used in the behavioural study. Examples of behavioural outcome measures are choices made by study participants or sales data, while examples of non-behavioural outcome measures include perceptions and attitudes (more detailed information on these steps can be found in the eligibility criteria we used for article selection in Appendix A). Studies which include such a non-behavioural outcome measure, but in addition also a behavioural outcome measure, were included in our selection.

Based on these selection criteria, we came to the search string as shown in Appendix B. The search string was used to search in the keywords, title, or abstract of the articles. For our search we used multiple electronic databases, Web of Science and Scopus, to gain more certainty that the relevant articles for our systematic review would emerge. We searched papers from 2016 until the latest available date on June 2, 2020. Only studies from approximately the last 5 years were included, to get an overview based on the latest and up-to-date scientific findings, but also because the development of Virtual Reality progressed rapidly (e.g., more widely available, and more immersive). We decided to incorporate studies since 2016 since in that year new VR headsets were released that resulted in an easier implementation of the technology in consumer research and that guaranteed a better and more believable user experience, such as the Oculus Rift of which a consumer version was released early 2016 (Desai et al., 2014). Therefore, we only included papers from this time span, to be able to establish the methodological validity of virtual reality and its behaviour change effectiveness of only the latest, state-of-the-art virtual reality instruments which are nowadays used on a wider scale. We searched for scientific articles written in English, as well as conference papers/proceedings. The latter type of papers were also searched for, because the topic of virtual reality in behaviour change research, and particularly the use of state-of-the-art VR headsets in this research, is relatively novel. At the same time, conference papers are typically peer-reviewed as well, similar to scientific articles.

The search terms were tested and refined through several rounds of paper identification, running the full search string in both electronic databases, until the resulting database was deemed sufficient in terms of number of papers, while simultaneously also demonstrating face validity (i.e. important key papers indeed emerged with our search string). The final search yielded 720 papers in Web of Science and 903 papers in Scopus, so 1623 papers in total. After removing all duplicate articles (471 articles), this resulted in 1152 unique articles.

2.2. Identification of relevant articles

We developed a protocol to identify the relevant articles to be included, through multiple rounds of screening the articles. First, articles were screened based on title. We established several eligibility criteria for title screening. Articles with titles that indicated that the study focused exclusively on children (<18 years) or a very specific target group (e.g. patients recovering from a specific disease) were excluded. Furthermore, since we focus solely on consumer behaviour, medical, nutritional and clinical studies are excluded. To operationalize what constitutes as a form of consumer behaviour, we used the criterion that the targeted behaviour in a study should (potentially) involve some kind of monetary expenditure. This monetary expenditure did not necessarily have to be part of the behavioural experiment/intervention itself, but there has to be some form of monetary expenditure involved in the behaviour in real-life. For instance, a behaviour change study in the field

of tourism that tests the use of Virtual Reality to increase the number of bookings to a city via a self-report measure would be included in our article selection, even if the actual booking (and thus monetary expenditure) was not measured in the study itself. The records of relevant articles from both databases were stored in Endnote. After the round of title screening, 136 of the 1152 articles remained for the next round of screening.

Next, the abstracts of the resulting set of articles that remained after the title screening round were screened for relevance and further inclusion. We used a "pilot run" in which a subset of papers was randomly selected from the database, and evaluated by each of the researchers involved in this task, to determine whether certain criteria needed further refinement and to ensure that the researchers used the criteria in a similar manner during the screening process. Based on this pilot run, the inclusion/exclusion criteria were further refined and finalised, leading to a criteria list that was used for coding the abstracts and full papers (Appendix A). In case a paper had multiple studies, in which not all studies were deemed relevant, the paper would still be included as long as at least one study was deemed relevant for the scope of the systematic review.

Two researchers independently coded all 136 abstracts for either inclusion or exclusion for the final set of papers. When in doubt, the coder could also mark an abstract as doubtful to be included. Inter-rater reliability between the coders was high: 0.963. For those articles where disagreement between coders occurred, discussion between the two researchers involved in coding was used to resolve the disagreement. Discussion was also used to discuss abstracts where one or both of the researchers marked a study as doubtful to include for the final set of papers. After the round of abstract screening, 43 articles remained for the next round of screening.

In the next round, full-text articles were obtained for all 43 articles that still remained after the two previous rounds of screening. Special attention was paid to the articles which already raised doubts during the abstract screening phase. Once again, two researchers independently coded these articles for inclusion/exclusion, this time based on the full-text. This round of screening the full-texts of the articles resulted in the final inclusion of 24 articles. Fig. 1 provides a flowchart of the article selection for inclusion of articles, throughout the various rounds of screening.

3. Results

3.1. Methodological validity of VR as a tool in consumer behaviour research

A total of 10 papers (11 experimental studies) explored the role of virtual reality (VR) with the primary aim to establish whether VR is a valid tool in consumer behaviour research in terms of being able to find similar effects compared to a non-VR setting (Table C1). Overall, the large majority of these studies used convenience samples, which for the most part were students. In only three papers, non-student samples were used, in the form of participants being recruited in a physical store or via a market research agency (Pizzi, Scarpi, Pichierri, & Vannucci, 2019; van Herpen, van den Broek, & van Trijp, 2016) or via a social media channel from a tourism office (Marchiori, 2018). Of these 10 papers, one paper was a conference proceedings paper (Cheah et al., 2019), with the other papers being published in a peer-reviewed journal.

In nine studies, outcomes were compared between a VR and a non-VR study in order to get an indication to what extent outcomes are similar, with the aim to explore to what extent VR can replicate findings compared to the same study being conducted in a non-VR setting (online or real-life): in six of these nine studies the outcomes were similar in terms of the behavioural outcome measure(s) of the study, indicating that findings from a non-VR online or real-life, physical setting can often be replicated in a VR setting. The other studies had mixed findings in terms of their ability to replicate findings in VR from the same study conducted
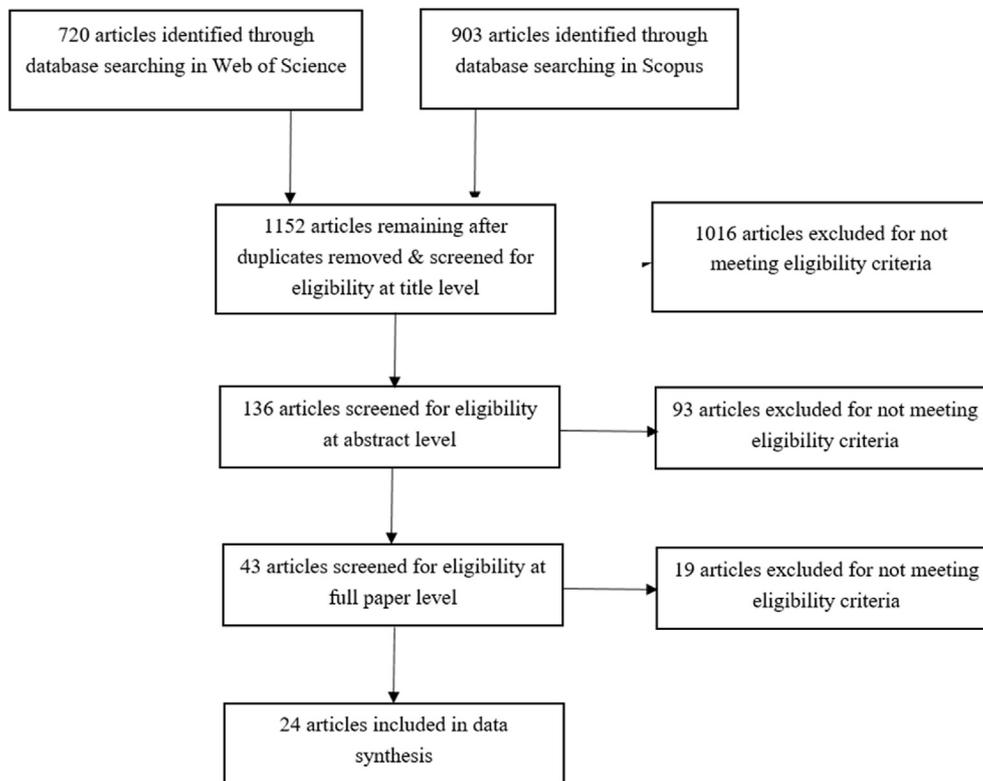
Fig. 1. Flow chart study selection.

in a non-VR setting.

3.1.1. Studies exploring the comparability of outcomes between a VR study and an equivalent, real-life study

In seven studies, outcomes were compared between a VR study and the same study in non-VR by means of a real-life study, all in the food domain. Four of these seven studies replicated the findings from the real-life study when conducting the same study in VR, whereas three studies found differences in part of the targeted behavioural outcomes. Based on these findings a (preliminary) conclusion can be drawn that study outcomes are quite comparable: these studies, though limited in number, indicate that outcomes from a real-life setting can mostly be replicated in a VR setting, suggesting that VR can accurately real-life consumer behaviour, at least in these instances. Cheah et al. (2019) used a within-subject design in which 11 participants were exposed to both a real-life buffet setting and a VR buffet setting. They found a high correlation between the total number of calories selected of all food items selected in the VR and real-life buffet settings (r = 0.64). Similarly, Ung, Menozzi, Hartmann, and Siegrist (2018) found that the amount of Kj of selected food was highly correlated for all types of food in the buffet (carrot, pasta, chicken), between participants making food choices in a (physical) fake food buffet and participants making choices in a VR food buffet. In two studies, it was demonstrated that participants' selection of cereals and the frequency with which participants looked at nutrition information on the cereal boxes did not differ between participants making decisions from a physical shelf and participants making decisions from a shelf in a VR setting (Siegrist et al., 2019).

Three studies found differences in at least one behavioural outcome between the VR study and the same study in real-life. In one of these studies participants purchased more fruits and vegetables when participating in an immersive virtual store (with the store being visualized via a VR Head-Mounted Display), relative to participants who were in a physical store (Lombart et al., 2020). Pizzi et al. (2019) found that participants spent more time in front of a shelf in a VR supermarket, compared to participants in an actual, real-life supermarket, which

according to the authors might have been partly a result of participants indicating to experience a higher level of excitement because of the novelty of VR. However, this study observed no difference between the volume of supermarket purchases between the VR supermarket and actual, real-life supermarket, so in terms of purchased volume the findings were the same in both settings (Pizzi et al., 2019). Finally, van Herpen, van den Broek and van Trijp (2016) showed that participants behaved similar in a VR supermarket and a real-life supermarket in terms of the number of products selected, the average price that participants paid per product, and their response to display characteristics (i.e. number of products selected from a certain shelf). However, differences were observed between participants in the VR supermarket and those in the real-life supermarket with regard to variety seeking (lower in real-life), the types of brands selected (less national brands selected in real-life), and their response to price promotions (less price promotion products selected in real-life).

3.1.2. Studies exploring the comparability of outcomes between a VR study and an equivalent, online study

Two studies compared outcomes between a study in VR and non-VR by means of an online study, with both studies replicating the findings from the online study when conducting the same study in VR. This indicates that consumer behaviour captured in an online environment, can also be captured in a VR environment, though based on just two studies this is only a very tentative indication. Naderi, Naderi, and Balakrishnan (2020) found no difference in the effects of both the level of design cues and congruency of the environment on purchase intention of the camera between participants participating online on a desktop PC, compared to participants who in a second, follow-up study conducted the same study, only then in VR. Jones, Barney, and Farmer (2018) also showed participants behaving the same when they were in a VR retail store, compared to participants conducting the study about the retail store via an online panel study, showing that purchase intentions of embarrassing consumer products is similar in the VR study and the online panel study.

3.1.3. Studies exploring the methodological validity of VR in other ways

In the two studies where no comparison was made between a VR and a non-VR condition, the question of whether VR is a valid tool in consumer behaviour research to capture real-life behaviour was explored in a different fashion. First, Park, Im, and Kim (2018) explored the use of VR by testing to what extent participants experience a sense of telepresence (i.e. the subjective experience of actually being in a certain environment) and whether this is related to behaviour. They showed that indeed there was a high correlation between telepresence, in their study measured as perceiving to actually be in a retail store, and participants' purchase intention of clothing from the store. Second, a case study of Marchiori, Niforatos, and Preto (2018) explored participants' intention to visit a place and to what extent this intention was based on a VR video in which this place was promoted. Almost all participants declared their intent to visit the destination, as a result of viewing this VR video (22 out of 23, only one person specified the intent to visit was not caused by viewing the video), while also reporting that participants overall experience a general feeling of immersion, suggesting that VR can be used in a valid manner for study participants to have the feeling they are actually in a different place.

3.2. Studies that apply VR to instigate behaviour change in consumer behaviour research

A total of 14 papers (16 experimental studies) applied a form of virtual reality (VR) to instigate behaviour change in a consumer domain (Table C2). In six papers, the sample was a general public sample (e.g. representative consumer panel or actual tourists that were recruited on-site on a tourist location), while in seven papers a student sample was used. One paper used a combination of a student sample and a general public sample (Nelson, Anggraini, & Schlüter, 2020). All papers were published in a scientific journal. A variety of consumer domains were covered in the 14 papers: four papers focused on food, four papers focused on a form of altruistic or pro-environmental action (e.g. monetary donations or water conservation measures), three on consumer products (clothing, mall shopping) and three on tourism.

Six of the 16 experimental studies had an experimental design which included only VR conditions (i.e. in each condition participants completed the study in VR). In the other experimental studies there were also one or more non-VR experimental conditions: in these studies, researchers for instance tested whether a treatment in VR was more effective in changing a targeted behavioural outcome than the same treatment in 2D such as in the form of a 2D photo, or a video shown on a desktop, as opposed to the same photo or video being shown via a head-mounted VR set for a different group of participants. This type of VR vs. non-VR comparison is different than in the studies in the previous section where the aim of this VR vs. non-VR comparison was to explore whether findings from a study conducted in a VR setting could replicate findings from the same study in a non-VR setting (such as in real-life), as opposed to VR being used as a tool to instigate greater levels of behaviour change relative to an equivalent treatment in non-VR (via for instance desktop or mobile phone).

3.2.1. Experimental studies with only VR conditions

Six experimental studies had an experimental design which included only VR conditions. Three of these six studies found significant effects on their targeted outcome variable(s). The overall picture based on these six studies is that VR can be an effective tool to instigate behaviour change in these VR-only studies, particularly considering that in all six studies VR was effective (albeit in three of those six studies, VR only led to behaviour change on part of the targeted behaviours). In the study of Ammann, Hartmann, Peterhans, Ropelato, and Siegrist (2020) participants either got exposed in a VR video to a virtual disgust cue (experimental group) or there was no cue (control group). They found that fewer participants ate the chocolate when exposed to a virtual disgust cue in a VR environment, compared to participants in the control group. Hsu, Tseng, and Kang

(2018) studied the effects of different types of feedback in a VR environment on participants' intention to conserve water. They found that direct exaggerated feedback (with information on negative consequences of water consumption) had the biggest change in behavioural intention for water conservation, relative to ambient exaggerated feedback (negative consequences on the environment) or either a combination of both or a control group. The study of Li and Chen (2019) had a 2×2 between-subject design (perceived enjoyment of VR manipulation: high vs low, with variation in screen resolution and price of the VR headset) x (Expected enjoyment of destination: high vs low, where either world renowned cherry blossoms or unfamiliar cherry blossoms were shown). They found that perceived enjoyment of VR, which also included a higher screen resolution, had a positive effect on intention to visit the destination depicted in the VR video. Enjoyment of the destination moderated this relationship: when the expected enjoyment of destination is low, higher perceived enjoyment of VR actually leads to a lower intention to travel to the destination.

Three of the six studies which only had VR conditions in their design showed mixed findings, though they all found that at least part of their experimental design affected behavioural outcome measures. Marcum, Goldring, McBride, and Persky (2018) demonstrated that the amount of calories in selected food from a VR buffet was lower when participants, all mothers with a BMI of 25+ who have a child, received information on both childhood obesity risk and personalized family risk, compared to participants in the control group who received no obesity-related information. However, when only information on childhood obesity risk was provided, the amount of calories from the selected food from a VR buffet did not differ from control participants. Goedegebure et al. (2020) explored whether popularity cues ("sold the most") affected participants' choice for either regular or light products. In the case of light products, more light products were chosen among participants in the condition where they were exposed to a popularity cue for diet products in VR, compared to either those exposed to a popularity cue for regular (non-diet) products in VR or a control group where no popularity cue was given. The results showed no significant effect on choices for regular products: participants who were exposed to a popularity cue for the regular product in VR did not choose this regular product more often, compared to the other conditions. Nelson et al. (2020) had participants view a VR video about coral reefs which was shot either unidirectionally (i.e. one video camera is facing only one direction at a single time) or in 360° film (i.e. a view in every possible direction is simultaneously being recorded), the idea being that a VR 360° film presents an even more immersive environment. Furthermore, the video used either a positive message frame (stressing environmental gains) or negative message frame (stressing environmental losses). Donation amount for a coral conservation organization was higher among participants who watched a VR 360° video, rather than a unidirectional VR video. However, message frame valence had no effect on donation amount in this VR experiment.

3.2.2. Experimental studies with a mixture of VR and non-VR conditions

10 studies had an experimental design which included one or more VR conditions, as well as one or more non-VR conditions, testing whether in certain situations higher degrees of immersiveness via VR can affect targeted forms of consumer behaviour to a greater extent than the same treatment in a non-VR format by means of for instance a desktop video or 2D photo (as opposed to the same video or photo in VR). Overall, seven of these 10 studies found significant effects on targeted outcomes. Three studies demonstrated more mixed findings, but to some extent found significant effects on the targeted behaviour. Combined, these 10 studies indicate that the use of VR is capable to instigate behaviour change to a greater extent in a consumer setting, relative to the situation where consumers are exposed to the same treatment in a non-VR, more traditional visual instrument such as a desktop video or 2D photo. This is the case for various types of consumer behaviour, such as in the context of tourism (Willems et al., 2019); Zeng, Cao, Lin, & Xiao (2020), monetary donations to a certain cause (Breves, 2020; Kandaurova & Lee, 2019) and

shopping for clothing (e.g. De Gauquier, Brengman, Willems, & Van Kerrebroeck, 2019; Moes & van Vliet, 2017).

Six studies had a VR condition and a non-VR condition by means of a desktop or mobile phone in its design. Four of these studies found only significant effects on targeted outcomes and two studies showed mixed findings. Purchase intention of outdoor clothing was significantly higher among participants who viewed an advertisement in VR, relative to participants who viewed the same advertisement in 2D on their mobile phone; brand attitude was also more positive when the advertisement was viewed in VR (De Gauquier et al., 2019). Zeng et al. (2020) conducted two studies in which they tested two variations of a VR intervention on participants' intention to book a hotel. Participants either saw high quality (i.e. insightful, objective) or low quality (i.e. irrelevant, subjective) (study 1) reviews of a hotel or a large or small quantity of hotel reviews (study 2), in combination with viewing the information about the hotel via a VR headset or on a desktop. In both studies, intention to book the hotel was higher when participants viewed the hotel in VR, compared to those who saw hotel information on the desktop. This effect was moderated by review quality (study 1) and review quantity (study 2): in the non-VR condition, intention was higher when review quality or quantity was high, whereas there were no effects of review quality or quantity in the VR condition. Combined, the studies of Zeng et al. (2020) indicate that VR can increase participants' intention to book a hotel, which can override any effects that hotel review quality or quantity can have on this intention. Breves (2020) tested the effects of varying degrees of immersiveness on donation behaviour by having participants watch a video about a refugee camp in either a high immersiveness setting (VR via HTC Vive), moderate immersiveness setting (VR via cardboard-style HMD with S5) or on a desktop (non-VR) in which viewers were asked to donate money. Participants who viewed the video in a high immersiveness setting requested more information via e-mail on the cause compared to the other two conditions, and on average they also donated a higher amount. However, no significant differences were found between conditions in the number of participants that decided to make a donation. In two studies, Kandaurova and Lee (2019) instructed participants to watch a video on a good cause and measured whether the amount of money that participants would donate and how much time they would spent volunteering for the cause, with part of the participants watching the video in VR, whereas other participants watched the same video on a laptop (non-VR). In one study, they found that participants who watched the VR video indicated to donate more time and money compared to those who watched the same video on a laptop, with VR thus being more effective in increasing both amount of time and money donated. In a follow-up study aimed to replicate these findings, the effects for volunteering time were replicated, but this time no difference was found in donation amount between conditions, in contrast to their initial study.

Two studies had a VR condition and a non-VR condition by means of a 2D photo in its design, of which one study found significant effects on targeted behavioural outcomes and one study showed mixed findings. Moes and van Vliet (2017) explored the extent to which participants' purchase intention and their intention to visit a physical fashion store is affected by whether they viewed either a virtual reality photo of the fashion store (3D), or the same photo in 2D in either a 360-degree format or a regular 2D photo. Participants who saw the 3D VR photo on average had a higher intention to visit the physical fashion store, relative to those who saw one of the 2D photos. Participants in the study of Andersen, Kraus, Ritz, and Bredie (2019) were exposed to a beach via either VR or a framed photo (experimental conditions), or they were not exposed as such (control). Self-reported desire for cold drinks was higher among participants exposed to a beach in VR, relative to both the photo condition and control condition; desire for cold drinks was lowest in the control condition. Self-reported desire for hot drinks was lowest in the VR condition, followed by the photo condition and then the control condition. However, there was no carry-over effect on actual behaviour: no significant differences were found between the conditions on choice of

chocolate (coconut chocolate or regular chocolate).

In one study, the experimental design had a VR condition and multiple non-VR conditions by means of a 2D photo and a desktop video. Willems et al. (2019) showed that participants in the VR condition in which participants made a virtual tour through a city reported greater feelings of telepresence (i.e. feeling of being there) compared to those in the two non-VR conditions (2D photos of the city or video about the city on desktop), which in turn was positively related to participants' intention to book a trip to the city which was visually represented.

Finally, one study had a quasi-experimental design in a real-life setting where participants could choose themselves whether they wanted a VR experience within this real-life setting (Van Kerrebroeck, Brengman, & Willems, 2017). Consumers who visited a shopping mall were approached to participate and consumers were exposed to a VR experience or not (where consumers chose for themselves whether to make a Virtual Reality sleigh ride in the shopping mall). Participants who had a VR experience scored higher on intention to return to the mall, compared to those who did not choose to make a sleigh ride in VR.

4. Discussion

Virtual reality (VR) is increasingly used in studies aimed to create behaviour change in consumer contexts, such as stimulating healthier food choices, finding ways to increase donations for certain causes, or promoting a touristic site in order to increase consumer bookings to this site. In this context, with our systematic review we aimed to: 1) examine to what extent studies have shown that VR studies in consumer domains are able to replicate findings from studies with the same set-up conducted in a non-VR setting (e.g. real-life, field setting), as a means to get an indication of the methodological validity to apply VR in consumer research aimed at behaviour change, and 2) examine the extent to which VR is an effective tool in itself to steer consumer behaviour in desired directions, relative to consumers being exposed to a same treatment in a non-VR manner such as viewing the same materials via videos or photos on a desktop or on a mobile phone instead of in a VR environment.

4.1. Main findings and implications

The large majority of the studies examining the methodological validity of using VR in consumer research aimed at behaviour change tested the validity of VR in terms of whether experimental study outcomes found in a real-life setting (e.g. a real-life, bricks-and-mortar supermarket, or restaurant) could be replicated when conducting the same study in VR, which were all studies in the context of consumer decision-making regarding food. Almost all of these experimental studies replicated study findings found in the real-life setting, when conducting the same study in VR. However, given that these studies were all in the food domain, this implies a need to explore to what extent similar conclusions can be drawn regarding the methodological validity of VR in other, non-food consumer domains. Furthermore, few studies explored the similarity in study findings, depending on whether the study was conducted in VR or in a different non-VR setting other than real-life, such as lab or lab-in-field studies. The few experimental studies that compared findings between a VR study and an equivalent online study did find similar findings in terms of the effect of the intervention on the targeted form of consumer behaviour. But overall, this suggests a scarcity of consumer studies examining whether findings from lab and/or online studies can be replicated when conducting the same study in a VR set-up. Voit, Mayer, Schwind, and Henze (2019) found that when comparing different methodologies of product evaluation that VR performs very similar to in-situ research, while it does not require a physical prototype. With their research, they suggest that VR is a competent methodology to analyze consumer evaluation of products (Voit et al., 2019). The overall ability of replicating consumer studies from real-life in VR does provide an initial indication that VR can be validly used in consumer research aimed at behaviour change in a consumer setting, though it is important to also

keep in mind that the number of studies is relatively low and were mostly conducted in the food domain. Furthermore, the large majority of studies examining the methodological validity of VR in promoting behaviour change in a consumer domain used a student sample, so based on these studies it cannot be stated yet whether similar conclusions could be drawn when using non-student samples that are more representative for the general population. Furthermore, generalizing these findings to other consumer domains is not straightforward, as there can be large differences in for instance characteristics of the decision-making environment (e.g. a supermarket has different characteristics than for instance a flower shop, or booking a holiday trip), so more research in other consumer domains is needed to adequately test the validity of using VR to capture behaviour in real-life settings, online settings and lab settings. In other, non-consumer domains, VR is often viewed as a tool that enables to capture real-life behaviour, for example when addressing research questions regarding human memory or clinical disorders (Parsons, 2015; Picard, Abram, Orriols, & Piolino, 2017; Reggente et al., 2018). However, in other non-consumer domains this has been the case to a lesser extent as the use of VR has for instance been less successful in replicating moral decision-making research conducted in non-VR (Ramirez, 2019). Further reason to be cautious before firmly establishing the methodological validity of using VR in behaviour change research in consumer domains are the small sample sizes which are often used in VR research (Lanier et al., 2019), which was also the case for many studies included in our review that examined the validity of VR.

All studies that used VR as a tool to steer consumer behaviour in a desired direction were effective in changing at least one of the target behaviours, with a minority of the studies finding more mixed results (i.e. they were not effective in changing all examined target behaviours). These intervention studies used various types of methodological design. Overall, studies show that when consumers are in an environment with a higher degree of immersiveness, this has the potential to affect their behaviour to a greater extent relative to less immersive environments. This indicates that VR has added value in facilitating behaviour change in consumer domains compared to less immersive contexts. For instance, studies in which consumers saw a video in VR generally led to a greater increase in desired forms of consumer behaviour relative to consumers viewing the same video on a desktop (e.g. Breves, 2020; Kandaurova & Lee, 2019). Furthermore, the type of VR can in itself also have varying degrees of immersiveness, with more immersive forms of VR, in terms of for instance higher-quality VR resolution, leading to greater behaviour change relative to less immersive forms of VR (lower quality or unidirectional VR). However, the amount of studies testing whether such more immersive forms of VR lead to greater behaviour change in a consumer domain is very limited (e.g., Breves, 2020; Nelson, Anggraini & Schlütter, 2020). Overall, these findings indicate that higher degrees of immersiveness indeed improve user experience (Patel, Bailenson, Hack-Jung, Diankov, & Bajcsy, 2006), which also improves the ability of VR as a tool to facilitate behaviour change in consumer domains. To a certain degree, higher degrees of immersiveness are connected to technological improvements in VR, which improves the VR quality and make the environment more immersive for users. However, the study of Nelson, Anggrani and Schlütler (2020) exemplifies that besides general technological advancements in VR, a VR environment can also be made more immersive for users by using a 360° VR film, instead of a more static, unidirectionally shot film. Other possible means to systematically increase immersiveness of VR to instigate even greater changes in forms of consumer behaviour, but as of yet under researched in the consumer domain, include interactivity within the VR environment (Felsberg, Maher, & Rhea, 2019; Siegrist et al., 2019). Flavián, Ibáñez-Sánchez, and Orús (2019) specifically elaborate on interactivity as the behavioural component in VR settings. Behavioural interactivity can have various degrees, ranging from relatively low (navigation control) to relatively high (as a user being able to control, and even modify the environment; Felsberg et al., 2019). Modifying an environment might not be desirable from a methodological perspective when designing an intervention, as

this alters the comparability between the study conditions, though this might also be used as a behavioural outcome measure (e.g., design the ideal supermarket, or which cues result in more sustainable solutions). However, the majority of VR interventions in the consumer domain included in our review have been relatively static, as they often involved watching a video or photo in VR. More interactive VR environments can potentially lead to greater changes in consumer behaviour. To illustrate, as a VR user being able to walk around in a certain environment such as part of a touristic site, might make this user even more inclined to book a trip to this site compared to watching a video in VR about this touristic site. One example of a consumer study in which more interaction was possible, was the study of Siegrist et al. (2019) where participants could walk around a bit in a VR supermarket and take products of a shelf. Future research can explore to what extent certain degrees of interactivity, such as a certain freedom to walk around in an environment or the opportunity to as a VR user make (modest) modifications to the VR environment, can increase the effectiveness of a VR intervention in creating behaviour change in a consumer domain. One notable consumer domain in which a VR intervention was relatively even more effective in changing behaviour is in the context of tourism. As tourism does not sell a haptic (i.e., touchable, tangible) product but rather an experience, the strategy implemented by tourism agencies or companies is to create a positive impression of the destination among consumers (e.g. Zeng et al., 2020). The more VR is used in an intervention in which the desired consumer behaviour is an experience, rather than a specific physical, tangible product (e.g. a physical product picked from a supermarket shelf), the more effective using VR might be. This also opens up an interesting balance for practitioners using VR to identify: at what point is the impression and seeming realism of a VR journey destination beneficial for the intent to travel to the destination and at what point is the experience in VR sufficient in itself that the intention to visit the destination is affected? The need to find a balance with regard to these two possibly opposing effects of VR is further amplified by the fact that this effect can potentially extent to other areas of the experience industry, such as theme parks, zoos and aquariums, as well as, concerts; future research can explore this in these non-tourism consumer domains aimed at selling an experience to consumers.

4.2. Limitations and future research

One notable limitation of this systematic review is that publication bias has likely inflated the results reported. As a result of publication bias effective studies are much more likely to be published (file-drawer effect; Rosenthal, 1979). Consequently, although based on our systematic review VR interventions appear to be relatively effective into changing certain forms of consumer behaviour, caution should be taken when interpreting these results. It is likely that the actual effectiveness overall is somewhat lower, as a result of this publication bias.

We purposely only included peer-reviewed articles to fulfill one the aims of this literature review by providing an overview of the effectiveness of VR in behaviour change research, based on papers that 1) are of sufficient quality based on the peer-review process, which given the relative novelty of VR studies in the context of consumer behaviour we deemed important in this still novel phase, 2) most researchers would come across when looking for suitable examples to inform their own research. Therefore, we had limited our review to the kinds of papers that would most likely be considered in such a situation and are methodologically sound based on peer-review, purposefully not addressing the file-drawer effect. This effect can be addressed in subsequent literature reviews and meta-analyses once the VR behaviour change literature has solidified and has become more mature. These future reviews can extend the included literature with more 'grey' literature, such as reports and unpublished manuscripts. Additionally, we carefully constructed our search string and search criteria, also after a pilot round to check whether further refinement was needed, while articles were searched in two comprehensive electronic databases (Web of Science and Scopus).

However, it is possible that a few relevant articles ultimately were not included in our final selection of articles that we included, a more general limitation of a systematic review. This would occur if none of the words present in the search string were used in the keywords, title and/or abstract of an article. In addition to the limitation of the file-drawer effect, in the case of VR further caution might be warranted when viewing the results regarding the effectiveness of VR as a behaviour change tool, because of the novelty of VR for study participants. Pizzi et al. (2019) speculated that the mere novelty of VR can already have an effect in itself on behaviour. This would imply that once consumers have been in a VR environment more often, it is possible that in some instances VR as a behaviour change tool becomes less effective. Furthermore, the papers included in our systematic review highlight a need to conduct future studies among more diverse populations, as many of the included studies used convenience samples in the form of students. This was particularly the case among the studies examining the methodological validity of VR in capturing actual behaviour in a consumer domain, which often also had relatively small sample sizes; a drawback of many VR studies also noted by Lanier et al. (2019). Specifically for VR, using samples that are more representative for the general public can be important, as issues such as motion sickness as a result of VR might vary across different types of individuals (Saredakis et al., 2020), though that is currently difficult to assess with such specific samples. A noticeable limitation to note of VR as compared to real-life consumer research methods is the limitation of the technology to only supply input for the visual and auditory senses. Compared to most non-real-life research methods or interventions, VR offers clear benefits, as these research methods also mostly focus on the visual senses. With the technology behind VR improving over the last few years and improving even further as this paper is being written, it can be expected that the advantage that VR has compared to the non-real-life research methods will only increase. Smell or haptic sensations are being excluded from the virtual reality environment in a VR setting. In certain contexts, consumers base their purchase decisions on a wider range of sensory inputs, such as when making certain food choices (Biswas & Szocs, 2019); VR will eventually fall short in addressing the role of these senses in such types of consumer contexts. As consumer research tries to understand and potentially replicate consumer decision-making in the real world, one has to acknowledge that VR is ultimately still an approximation of reality, no matter how much detail can be seen in the pixels of the headset screen. It is generally costly in terms of time, effort and money to design a very realistic environment within VR (van Gisbergen et al., 2019). Also with smell and touch not being addressed by VR, real-life experimentation will remain the most accurate mean to study consumer behaviour, particularly in consumer contexts where these sensory components are relevant in guiding consumer choices. However, VR does offer a good trade-off, as it is cheaper to implement than real-life experiments and offers a wider range of research questions that can be addressed, while it is generally more competent in delivering a holistic experience than other visual methods of consumer research.

4.3. Research agenda

Several research gaps can be identified based on the included studies in our systematic review, some of which were already shortly touched upon in our discussion of the implications of the main findings; addressing these research gaps can provide directions for future research in a way that contributes to the further advancement of behaviour change research in which VR is used within consumer domains. The different recommendations described in this research agenda can be characterized as either managerial, methodological or theoretical, as summarized and outlined in Table 1.

First, to elaborate a bit further on some points mentioned in our discussion of the main implications, relatively few studies examined the validity of using VR in behaviour change research in consumer domains, mostly while using small student samples. To further enhance this field of

Table 1

Recommendations for VR use in consumer research (based on the proposed research agenda).

Managerial recommendations	Methodological recommendations	Theoretical recommendations
Internal training or hiring of a dedicated VR programmer to support other researchers within a given organization	Using more diverse and representative samples that do not have a high VR affinity	Extending current research paradigms by new means to measure behaviour and to validate hypotheses
Development of a dedicated VR researcher's toolbox to facilitate R programming	Using more interactive VR environments to increase perceived realism	Combining different sources of rich data to create new methods of testing hypotheses
Training researchers on possibilities of using VR in their research methodologies	Using an easily replicable setting as a new approach to validate findings in follow-up experiments or replication studies	Validating new stimuli that can be used as manipulations in an experimental setting

research, establishing the validity of the use of VR in terms of VR research being able to replicate consumer behaviour from real-life studies, the use of larger and more representative samples is ultimately needed as it is not straightforward that replication of consumer behaviours of students, mostly young and highly educated consumers, implies that similar consumer behaviours of more representative samples can also be replicated. Particularly now mostly younger consumers also gradually use VR more often in their personal lives, for instance for playing games or watching movies, this leads to the question whether older consumers would behave in the same manner in VR research that attempts to replicate study findings from real-life or lab research.

Second, the research included in our systematic review that used VR as a behaviour change tool, overall had relatively static environments. The VR environment often was operationalized in terms of a video or photo being viewed in VR. However, as was also noted by Siegrist and colleagues (2020), VR offers more possibilities for consumer research, in terms of providing more interactive possibilities within the VR environment. Including such possibilities can further increase the realism of the VR environment, as in real-life consumers also have these interactive possibilities with their environment (e.g., picking items from a shelf, picking up a product and looking at it from different angles). Furthermore, a more interactive environment can also allow for the introduction of new manipulative stimuli. For example, the Stanford laboratory has developed unique fear stimuli to elicit a fear response in VR. They have for instance generated video material that lets participants experience a dog attack, the presence of very large spiders, and a dive with great white sharks in VR (Balban et al., 2021). These manipulations cannot be adequately reproduced without using VR as a medium. Implementing these types of manipulations in VR can allow to reproduce experimental findings more easily, as the sharing of the stimulus or the VR environment is often sufficient to replicate the experimental environment with a high degree of fidelity. Possibly, one of the reasons complex and interactive VR environments as well as stimuli are relatively scarce, has to with the type of skills needed to design a realistic-looking VR environment with these possibilities. Our next point further addresses this.

Third, VR is slowly seeing an increasing uptake in the consumer research literature, but it is not yet a mainstream tool among researchers studying consumer behaviour. As this will likely change throughout the next years, due to technological developments resulting in better and cheaper VR headsets, researchers will also need added tools to design this type of research in the near future. In the long-term, as VR is a new technology with new and different technological requirements for researchers that want to use or program it, it is of paramount importance to make the use of VR as easy as possible for researchers who are not too technically savvy. The easier VR is to adopt, the more likely the role of VR in consumer research will expand and the more the field will learn about

benefits and hidden costs of VR technology. Historically, software that is needed to create realistic 3D VR environments with interactive possibilities in the VR environment is made for game designers; consequently, this software requires specific programming skills that most behavioural scientists do not possess. We recommend the development of a VR consumer researchers' toolbox that contributes to an easy-to-implement and easy-to-use development of a VR environment, which can encourage (rather than discourage) consumer behaviour scientists to use VR in behaviour change research. The development of a researcher's toolbox has historically facilitated the uptake of novel technologies in a research domain; initial attempts for such a toolbox have already been made in the VR domain, also for behavioural scientists (Brookes, Warburton, Alghadier, Mon-Williams, & Mushtag, 2019; Vasser, Kängsepp, Kilvits, Kivisik, & Aru, 2015). As this is a somewhat abstract recommendation that cannot be developed by a single researcher or organization that does not want to specialize too extensively in VR, we recommend some more direct steps to take, such as to either hire or internally train a dedicated VR programmer. Such a specialized employee considerably lowers the threshold for researchers to engage in new VR projects. Specifically, the VR programmer should focus on recommending how to integrate VR in already existing research paradigms to potentially strengthen their external validity. Any research manager can use such a specialized employee or researcher to strengthen the research output of their research group or lab across a wide range of projects. Having one VR expert in a laboratory can also facilitate the learning process for other researchers, so that they have an increased disposition to likely include VR as a methodology. Such an approach to VR should also take into account the amount of data that is produced in addition to the normal data points generated by consumer research. Once VR is more broadly introduced to a scientist's experiments, much more different data is usable for analysis than in a traditional consumer research setting, such as EEG, movement, or distance measures data. It can become a challenge for consumer researchers to integrate such vastly different kinds of data into the available analysis tools without expanding their analytic toolbox. These data driven insights need to be then matched with results from surveys and the results from different methodologies to provide a reliable image of the different data types assembled. With an easy-to-implement API between a VR toolbox and R for example, or a specialized R package, this vast amount of data can more easily be integrated and analyzed. If consumer researchers were to conduct research using such data-producing tools, novel analyses methods would recommend themselves too. A VR toolbox, with a vast amount of data might allow to use machine learning algorithms as a new staple of consumer analysis.

Fourth, beyond the technical aspects of VR, it is important that current behavioural research frameworks are extended or adapted to include VR in their scope, so that more consumer behaviour researchers become familiar with the possibilities of VR in behaviour change research. When prominent frameworks such as the Behaviour Change Wheel (Michie, Van Stralen, & West, 2011) were developed, VR research was still scarce and was not as advanced yet as in current years, particularly since the arrival of head-mounted displays (HMDs; Desai et al., 2014). Since that moment, VR has shown rapid improvements in terms of being able to present a realistic-looking environment to users. This has likely strongly contributed to the use of VR as a behaviour change tool becoming increasingly effective in instigating behaviour change, because of the capability to make the VR environment more immersive, as could also been seen in this systematic review for this type of research in consumer domains. Existing behaviour change frameworks such as the Behaviour Change Wheel can be extended/adapted in order to include VR as a behaviour change tool in itself, in order to embed VR as a methodological tool that can be deployed to change behaviour in certain situations. To illustrate this point using the Behaviour Change Wheel, including VR can either be an extension to change existing categories in a way that they can include VR as a tool for behaviour change or to create novel categories so that they can accommodate VR as a new technology.

Fifth, we suggest that researchers accumulate behavioural paradigms that were too difficult or too unethical to investigate without VR as a technology. As an example, researchers interested in how a consumer changes their purchase decision while experiencing a believable conflict in a shopping environment now has a means to realistically investigate such a research question without putting the participant in a actual, real-life potentially distressing conflict situation. Thus, the use of VR can expand the type of research questions within the field of consumer behaviour even further than is currently the case.

5. Conclusions

In conclusion, the literature review reveals that within behaviour change research in consumer domains, findings in VR environments generally mimic the findings from equivalent studies in real-life settings. Therefore VR can potentially be used as a more efficient, more controllable environment to test interventions in. It is important to keep in mind though that these type of studies are still relatively scarce in consumer domains, have mostly used small student samples and have so far been mostly conducted in the food domain. Furthermore, VR has already proven to be an effective tool to support behaviour change in a variety of consumer domains, such as food, clothing and tourism. The more immersive the VR context is, the more effective interventions typically become in the extent to which behaviour change is realized. Technological developments are following each other rapidly. At the moment, the full potential of VR is not yet used often in consumer research, for instance in terms of its interactive capabilities, but that is also likely a result of the novelty of this technology in this type of research. The current review shows that although there are many research gaps and critical notes, the use of VR for consumer research seems highly relevant to further advance the field of consumer studies that aim to promote behaviour change.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Acknowledgements

Appendix A. Eligibility criteria for article selection

Code	Explanation	Exclude if	Do not exclude if
(1) Duplicate	Article is a duplicate of an article encountered above	Scopus and Web of Science have different ways of dealing with special characters (ö etc.).	
(2) Lookup	Article does not provide an abstract	No exclusion – but end of coding at this stage as we have agreed not to judge on title alone	
(3) No English	Abstract/article is not in English	Abstract is not in English	

(continued on next column)

(*continued*)

Code	Explanation	Exclude if	Do not exclude if
(4) No results	Abstract/article does not have results yet	Abstract/article does not have results yet and only describes why the study is interesting and how it would contribute	
(5) Specific target group	Article focuses on specific target group	Exclude papers that exclusively deal with the following specific target groups: - Children (<18 yrs) - Patients with specific diseases (e.g., diabetes, cancer) - People with an individual risk of a disease (e.g. hypertension, obesity) - People recovered/recovering from a disease	Include papers dealing with: - Samples where just a part of the sample comes from of a specific target group (e.g. age ranges from 14 to 80y) - People at elderly homes, etc. - People with an increased risk of a disease on a group-level (e.g. fire fighters or a subset of citizens who statistically have a higher odds of a disease)
(6) No experimental study	No experimental studies are reported in paper	Exclude papers in which no experimental study is reported: - Non-empirical studies (literature overviews, reviews, etc.) - Qualitative studies - Other quantitative studies (modelling, correlational, etc.) - Choice-experiment	Include papers with: - Experimental designs (between-subject & within-subject) - Quasi-experimental designs - Pre-post-test designs (also when there is no control group)
(7) No VR study	No VR studies are reported in paper	Exclude papers in which no VR study is reported:We define VR as all experiments that use virtual reality or VR in their experiment or paper description	
(8) No behavioural outcome measure	No behavioural outcome measure(s) are reported in paper	Exclude papers in which no behavioural outcomes are reported. Examples of non-behavioural outcome measures are: - Attitudes & opinions - Perceptions	Include papers that focus on for instance: - Choice - Sales - Objective measures like: BMI, health status, etc. - Preferences - Behavioural intention
(9) No consumer study	The reference is outside the domain of consumer studies on the behavioural outcome(s) cannot be established	Exclude the following papers: - Medical (i.e., effect of food on human physiology) and nutritional papers - Papers on animal subjects	Include papers that focus on: - All forms of behaviour that ultimately include a form of monetary expenditures
(10) No access to full paper	When there is no (free) access to the full paper		
(11) Doubt	When still in doubt whether to include or exclude		
Include	Everything not excluded based on above		

Appendix B. Search criteria and string used in Web of Science and Scopus

Search string
Web Of Science (TS = topic; title, abstract, keywords, indexing fields)
TS=((intervention* OR experiment* OR "control group" OR "control condition" OR "treatment group" OR "treatment condition" OR "intervention group" OR "intervention condition" OR "pretest" OR "pre-test" OR "posttest" OR "post-test") AND (behav*) AND ("virtual reality")) 'Document type': Article Language: English Year: 2016 till June 2, 2020
Scopus (TITLE-ABS & AUTHKEY)
PUBYEAR > 2015 AND (TITLE-ABS (intervention* OR experiment* OR "control group" OR "control condition" OR "treatment group" OR "treatment condition" OR "intervention group" OR "intervention condition" OR "pretest" OR "pre-test" OR "posttest" OR "post-test") OR AUTHKEY (intervention* OR experiment* OR "control group" OR "control condition" OR "treatment group" OR "treatment condition" OR "intervention group" OR "intervention condition" OR "pretest" OR "pre-test" OR "posttest" OR "post-test")) AND (TITLE-ABS (behav*) OR AUTHKEY (behav*)) AND (TITLE-ABS ("virtual reality") OR AUTHKEY ("virtual reality")) 'Document type': Article Language: English Year: 2016 till June 2, 2020

Appendix C

Table C1
Studies that examine the validity of VR in consumer behaviour research

Author(s) & Year	Target group	Sample size	Experimental design & conditions	Target behaviour (or behavioural intention)	Type of VR	Effect of intervention on behaviour (or behavioural intention)	Comparison of VR to non-VR
Cheah et al. (2019)	Convenience sample: students	n = 11	Within-subject design: 1. VR buffet setting 2. Real-life buffet setting	Actual behaviour (Kcal/gram of food selections)	Unspecified	The correlation between the total number of calories selected in the VR and RL buffets was large in magnitude, r = .64.	High correlation in density of food selection between VR and non-VR (real-life).
Esmark Jones et al. (2018)	Convenience sample: students	n = 44	VR study (study 3 in paper) seeking to replicate results from previous study (reported in same paper)	Actual behaviour (product choice)	Head-mounted VR gear	VR study replicated the effect of other studies in the same paper: participants rather choose neutral colours for embarrassing products.	Similar results across different studies (VR study vs. online panel study).
Lombart et al. (2020)	Convenience sample: students	n = 192	Between-subject design: 1. Physical store 2. Non-immersive virtual store (store on screen) 3. Immersive virtual store (store in Oculus Rift)	Purchase intention of fruits & vegetables	Head-mounted VR gear (condition 3)	Consumer purchased more fruits and vegetables in the two virtual conditions than in the physical store condition.	Consumer purchased more fruits and vegetables in the two virtual conditions than in the physical store condition. However, consumer perceptions of fruits and vegetables (price fairness, perceived healthiness and hedonism) are similar across conditions.
Marchiori et al. (2018)	General public (recruited via Facebook page tourism office)	n = 23	Within-subject design (pre-test post-test measures before and after watching a VR video)	Behavioural intention to visit a place	Head-mounted VR gear	Almost all participants declared their intent to visit the destination (22 out of 23, only one person specified the intent to visit was not caused by viewing the video).	Not applicable, only VR.
Naderi et al. (2020)	Convenience sample: students	Study 1 (non-VR: 3D display on desktop): n = 91 Study 2 (VR): n = 90	2 × 2 Between-subject design: (high-level design cues of camera vs. low-level design cues of camera) x (congruent environment vs. non-congruent environment)	Purchase intention to buy the camera	Head-mounted VR gear (Study 2)	There were no main effects on purchase intention (both in Study 1 and 2). The interaction between product design and environmental congruence had a significant effect on purchase intention in both studies.	Overall, VR had a stronger effect on purchase intention than the display of the product on a desktop screen.
Park et al. (2018)	Convenience sample: students	n = 40	Between-subject design: 4 different types of VR store environments/layouts *Nb.: two store models were designed based on natural design themes, while the other two store models reflected modern design themes*	Intention to purchase products in the store	Head-mounted VR gear within VR Design Lab	Significant correlation between telepresence (i.e. feeling of being there) and purchase intention: r = .47. No significant mean difference in the measured variables among the four VR stores.	Not applicable, only VR.
Pizzi et al. (2019)	General public (recruited in physical store, or via market research agency)	n = 100	Quasi-experimental between-subject design: 1. Physical grocery store 2. Virtual reality grocery store	1. Time spent in front of shelf 2. Purchased volume (in total)	Head-mounted VR gear	1. Time spent in front of shelf was significantly longer in the VR condition (M = 131s), than in the physical store (M = 89s). 2. Purchased volume did not differ between conditions.	There was no difference in purchase volume in grocery store shopping between the VR and non-VR condition, but average time spent in front of the shelf was longer in the VR condition.
Siegrist et al. (2019)	Convenience sample: students	Study 1: n = 37 Study 2: n = 50	Study 1, between-subjects design: 1. Real-life supermarket 2. Virtual reality supermarket Study 2, between-subjects: 1. VR healthy condition (instruction to select healthy product)	Study 1: 1. Selection of cereals (actual behaviour) 2. Frequency of information seeking (eye tracking) Study 2:	Head-mounted VR gear	Study 1: 1. No statistically significant differences were observed in the selection of the cereals between conditions. 2. Frequency with which participants looked at nutrition information was not significantly different	No difference in cereals selection or frequency of looking at nutrition information between VR and non-VR condition (real life).

Table C1 (*continued*)

Author(s) & Year	Target group	Sample size	Experimental design & conditions	Target behaviour (or behavioural intention)	Type of VR	Effect of intervention on behaviour (or behavioural intention)	Comparison of VR to non-VR
			2. VR taste condition (instruction to select tasty product)	1. Selection of cereals (actual behaviour) 2. Time spent on information seeking		between the two groups. Study 2: Participants in the health condition selected cereals with significantly less sugar and significantly more fiber compared with participants in the taste condition.	
Ung et al. (2018)	Convenience sample	n = 34	Within-subject design: 1. Virtual reality food buffet 2. Fake food buffet	Kj of selected food items (carrot, pasta, chicken, total) (actual behaviour)	Head-mounted VR gear	The amount of Kj of selected food was significantly correlated for all types of food between the two conditions: carrot (r = .77), pasta (r = .75), chicken (r = .75), total (r = .81)	Significant correlation in Kj of selected food between VR condition (virtual food buffet) and non-VR condition (fake food buffet).
van Herpen, van den Broek, van Trijp, and Yu (2016)	General public (recruited from a consumer panel)	n = 100	Between-subject design: 1. Physical supermarket 2. Virtual supermarket 3. 2D pictorial representation of supermarket	1. Number of products selected 2. Level of variety seeking 3. Types of brands selected 4. Amount of money spent 5. Response to price promotions 6. Response to display characteristics	VR on desktop (lab)	1. Number of products does not significantly differ between the physical and virtual supermarket (but is higher in the 2D picture supermarket condition) 2. Higher level of variety seeking in both lab conditions (2D picture, VR) than in physical supermarket 3. Less national brands were selected in physical supermarket than in both lab conditions (2D picture, VR) 4. Average price paid per product did not differ across conditions 5. More price promotion products were selected in both lab conditions (2D picture, VR) than in physical supermarket 6. Amount of products selected from a left shelf did not differ between the VR and physical supermarket; higher in 2D picture supermarket condition. Similar, amount of products selected from a top shelf did not differ between the VR and physical supermarket; higher in 2D picture supermarket condition.	Similar findings between the VR condition and non-VR (real-life) condition in terms of number of products selected, average price paid per product, response to display characteristics. Different findings between the VR condition and non-VR (real-life) condition in terms of variety seeking, types of brands selected, and response to price promotions.

Table C2
Studies that apply VR to instigate behaviour change in consumer behaviour research

Author(s) & Year	Target group	Sample size	Experimental design & conditions	Target behaviour (or behavioural intention)	Type of VR	Effect of intervention on behaviour (or behavioural intention)	Comparison of VR to non-VR
Ammann et al. (2020)	General public (recruited via online advertisements, or via research group's experimental panel)	n = 100	Mixed reality design, combining VR with objects in the real world: 1. Disgust group: virtual disgust cue	Choice to eat chocolate or not (actual behaviour)	Head-mounted VR gear	Participants in the experimental condition were significantly more likely to refuse consumption of the	Not applicable, only VR.

Table C2 (*continued*)

Author(s) & Year	Target group	Sample size	Experimental design & conditions	Target behaviour (or behavioural intention)	Type of VR	Effect of intervention on behaviour (or behavioural intention)	Comparison of VR to non-VR
			2. Control group: no virtual disgust cue			chocolate compared to participants in the control condition.	
Andersen et al. (2019)	General public (recruited via local advertisements, or consumer database at the Department of Food Science, University of Copenhagen)	n = 60	Within-subject design: 1. Exposure to sun/beach via immersive virtual reality (VR) 2. Exposure to sun/beach via a framed photo (physical photo/no VR) 3. No exposure: Default ambient room condition (neutral)	1. Choice of chocolate (actual behaviour: Bounty, Snickers, Twix) 2. Self-reported desire for a variety of cold or hot drinks (coffee, tea, juice, soda and beer)	Head-mounted VR gear	1. No significant differences between conditions on choice of chocolate 2. Self-reported desire for cold drinks is higher in VR condition, relative to physical photo/no VR condition, and lowest in neutral condition. Vice versa for hot drinks desire (lowest in VR).	No difference on actual behaviour (choice of chocolate), but desire for cold (hot) drinks was higher (lower) in VR condition than in non-VR condition.
Breves (2020)	Convenience sample: students	n = 85	Between-subject design: 1. High immersive VR (HI; HTC Vive) 2. Moderate immersive VR (MI; cardboard-style HMD with S5) 3. Low immersive (LI; control, computer desktop)	1. Request for more information via e-mail about foundation (yes/no) 2. Willingness to make a monetary donation to foundation (yes/no) 3. Amount of monetary donation (actual behaviour)	Head-mounted VR gear	1. Higher immersive (HI) VR led to more information requests (compared to MI and LI); no difference between MI and LI. 2. No difference in number of donations between conditions. 3. Donation amount was higher in HI VR, but only compared to MI VR.	Higher immersive (HI) VR led to more information requests than LI (Desktop; non-VR)
De Gauquier et al. (2019)	Convenience sample: students	n = 160	Between-subject design: 1. VR advertisement 2. 2D advertisement (YouTube video on mobile phone)	1. Purchase intention of advertised product (outdoor clothing)	Head-mounted VR gear	Purchase intention of the advertised product was significantly higher for the VR advertisement ($M_{VR} = 4.23$) than for the 2D, mobile phone advertisement ($M_{2D} = 3.62$).	VR advertising led to a higher purchase intention than 2D advertising, but also to a more positive brand attitude ($M_{VR} = 5.40$ vs. $M_{2D} = 4.89$).
Goedegebure et al. (2020)	General public (recruited via market research agency)	n = 300	Between-subject design: 1. VR popularity cue ("sold the most") for regular product 2. VR popularity cue ("sold the most") for light product 3. VR without any popularity cue (control)	Choice of product (regular, light, other)	Head-mounted VR gear	No significant effect of the popularity cue on amount of choices in the regular product conditions, relative to other conditions. However, more participants chose light products in the VR popularity cue in the light product condition.	Not applicable, only VR.
Hsu et al. (2018)	Convenience sample: students	n = 165	Between-subject design: 1. Exaggerated feedback (EF) on negative consequences of water consumption (direct EF) 2. Exaggerated feedback (EF) on negative consequences on the environment (ambient EF) 3. Direct EF + ambient EF 4. No direct, nor ambient EF	Behavioural intention to reduce water usage	Head-mounted VR gear	Direct EF had the biggest change in behavioural intention for water conservation. However, ambient EF had a long-term effect on water preservation intention (1 month later).	Not applicable, only VR.
Kandaurova and Lee (2019)	Convenience sample: students	Study 1: n = 53 Study 1: n = 122	Study 1: Between-subject design: 1. VR condition: watch video in VR 2. Non-VR condition: watch video on laptop screen Study 1: 2 × 2 Between-subject design (VR or Non-VR x social inclusion or social exclusion)	1. Self-reported amount to donate to cause (no actual donation; $1–100) 2. Self-reported amount of hours to volunteer for the cause (1–24hrs)	Head-mounted VR gear	Study 1: Participants in the VR condition indicated higher willingness to donate and to volunteer more time towards the social cause ($38.12 and 12.96hrs), than in the non-VR condition ($15.67 and 8.41hrs). Study 2: No significant differences between conditions on	VR led to higher self-reported volunteering time, relative to non-VR in both studies. VR also lead to a higher donation amount relative to non-VR, but only in Study 1.

Table C2 (*continued*)

Author(s) & Year	Target group	Sample size	Experimental design & conditions	Target behaviour (or behavioural intention)	Type of VR	Effect of intervention on behaviour (or behavioural intention)	Comparison of VR to non-VR
						amount to donate. The amount of hours to volunteer was significantly higher in the VR relative to non-VR condition, as also in the social exclusion relative to social inclusion condition.	
Li et al. (2019)	Tourists at scenic areas in China	n = 200	2 × 2 Between-subject design: (perceived enjoyment of VR: high, low) x (Expected enjoyment of destination: high, low)	Intention to travel to the destination shown in VR video	Head-mounted VR gear	Perceived enjoyment of VR has a positive effect on travel intention. Enjoyment of destination moderated this relationship: when the expected enjoyment of destination is low, higher perceived enjoyment of VR actually leads to lower travel intention.	Not applicable, only VR.
Marcum et al. (2018)	Mothers with BMI > 25 & at least 1 child age 4 or 5	n = 221	Between-subject design: 1. Control information 2. Childhood obesity risk 3. Childhood obesity risk + personalized family risk	Number of calories of selected food	Head-mounted VR gear	Fewest calories in selected food among participants who received info on childhood obesity risk + personalized family risk.	Not applicable, only VR.
Moes and van Vliet (2017)	Convenience sample: students	n = 107	Between-subject design: 1. VR photo of fashion store (3D) 2. 360° photo of fashion store (2D) 3. Regular photo of fashion store (2D)	1. Purchase intention 2. Intention to visit the physical fashion store	Head-mounted VR gear	1. Purchase intention was higher in the VR photo condition than in the 360° photo condition. No significant difference between the other conditions. 2. Intention to visit the physical fashion store was higher in the VR photo condition, compared to both the 360° as well as regular photo condition.	Higher intention to visit the store in VR condition, compared to both non-VR conditions. Purchase intention was higher intention in VR condition, compared to 360° photo condition, but not compared to regular photo condition.
Nelson et al. (2020)	Students (recruited on campus) & general public (recruited in outdoor public park)	n = 1006	Between-subject design: 2 × 2 design (360° video or a unidirectional video x positive or negative message frame: environmental gains or losses)	Donation amount for coral conservation organization	Head-mounted VR gear	Donation amount was higher among participants who watched a 360° video in VR, rather than a unidirectional video in VR. No significant differences between a positive and negative message frame in the video.	Not applicable, only VR.
Van Kerrebroeck et al. (2017)	Shopping mall visitors	n = 183	Quasi-experimental between-subjects design: 2 × 2 design (shoppers exposed to VR or not exposed to VR x low perceived crowding or high perceived crowding; based on median split)	1. Self-reported approach behaviour (i.e. liking to spend time in the mall) 2. Loyalty intention (i.e. intention to continue visiting the mall)	Head-mounted VR gear	1. No significant differences between conditions on approach behaviour. 2. Loyalty intentions were higher for participants who had a VR experience (M = 4.95), compared to those who did not (M = 4.52). This effect was moderated by perceived crowding, i.e. stronger among those who perceived the mall as more crowded.	No difference in approach behaviour between VR and non-VR conditions. Loyalty intentions were higher in VR condition.
Willems et al. (2019)	Convenience sample: students	n = 182	Between-subject design, in which a city is visually represented via: 1. photographs 2. 360° video 3. VR	Purchase intention to book a trip to the city	Head-mounted VR gear	In the VR condition, feelings of telepresence (i.e. feeling of being there) are higher relative to the other conditions, which in turn is positively related to online purchase	Stronger feelings of telepresence in VR condition, than in the non-VR conditions.

Table C2 (*continued*)

Author(s) & Year	Target group	Sample size	Experimental design & conditions	Target behaviour (or behavioural intention)	Type of VR	Effect of intervention on behaviour (or behavioural intention)	Comparison of VR to non-VR
						intention. *Nb. Direct effect of conditions on purchase intention are not reported.*	
Zeng et al. (2020)	Convenience sample: students	Study 1: n = 224 Study 2: n = 264	Study 1: Between-subjects design; 2 (hotel review quality: high or low) × 2 (virtual reality application: yes or no) Study 2: Between-subjects design; 2 (hotel review quantity: large or small) × 2 (virtual reality application: yes or no)	Intention to book the hotel	Head-mounted VR gear	Study 1: Higher intention to book the hotel in the VR condition, compared to the non-VR condition. Interaction review quality x VR/non-VR: in the non-VR condition, intention was higher when review quality was high; review quality had no effect in the VR condition. Study 2: Higher intention to book the hotel in the VR condition, compared to the non-VR condition. Interaction review quantity x VR/non-VR: in the non-VR condition, intention was higher when review quantity was high; review quantity had no effect in the VR condition.	Higher intention to book the hotel in the VR condition, compared to the non-VR condition.

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